OIPE IAP38 MAY 30 2006 PATENT & TRADEMARK OFFICE

PTO/SB/17 (01-06)
Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no person are required to respond to a collection of information unless it displays a valid OMB control number.

Effective on 12/08/2004.
Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).

FEE TRANSMITTAL
For FY 2006

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 500.00

Complete if Known	
Application Number	09/653,561-Conf. #5354
Filing Date	August 31, 2000
First Named Inventor	Larry Hillyer
Examiner Name	H. T. Nguyen
Art Unit	2812
Attorney Docket No.	M4065.0239/P239

METHOD OF PAYMENT (check all that apply)

☐ Check ☒ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): ____

☐ Deposit Account Deposit Account Number: 04-1073 Deposit Account Name: Dickstein Shapiro Morin & Oshinsky LLP

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☐ Charge fee(s) indicated below
☐ Charge fee(s) indicated below, **except for the filing fee**
☐ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR 1.16 and 1.17
☒ Credit any overpayments

FEE CALCULATION (All the fees below are due upon filing or may be subject to a surcharge.)

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES		SEARCH FEES		EXAMINATION FEES		
Application Type	**Fee ($)**	**Small Entity Fee ($)**	**Fee ($)**	**Small Entity Fee ($)**	**Fee ($)**	**Small Entity Fee ($)**	**Fees Paid ($)**
Utility	300	150	500	250	200	100	
Design	200	100	100	50	130	65	
Plant	200	100	300	150	160	80	
Reissue	300	150	500	250	600	300	
Provisional	200	100	0	0	0	0	

2. EXCESS CLAIM FEES

Fee Description	**Fee ($)**	**Small Entity Fee ($)**
Each claim over 20 (including Reissues)	50	25
Each independent claim over 3 (including Reissues)	200	100
Multiple dependent claims	360	180

Total Claims		**Extra Claims**		**Fee ($)**		**Fee Paid ($)**
122	- 133 =		x		=	

HP = highest numer of total claims paid for, if greater than 20.

Indep. Claims		**Extra Claims**		**Fee ($)**		**Fee Paid ($)**
13	- 15 =		x		=	

HP = highest numer of independent claims paid for, if greater than 3.

Multiple Dependent Claims

Fee ($)	**Fee Paid ($)**

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets		**Extra Sheets**		**Number of each additional 50 or fraction thereof**		**Fee ($)**		**Fee Paid ($)**
	- 100 =		/50		(round **up** to a whole number) x		=	

4. OTHER FEE(S) **Fees Paid ($)**

Non-English Specification, $130 fee (no small entity discount)

Other (e.g., late filing surcharge): 1402 Filing a brief in support of an appeal 500.00

SUBMITTED BY					
Signature		Registration No. (Attorney/Agent)	28,371	Telephone	(202) 828-2232
Name (Print/Type)	Thomas J. D'Amico			Date	May 30, 2006

DSMDB-2092889v01

OIPE IAP38
MAY 3 0 2006
PATENT & TRADEMARK OFFICE

TRANSMITTAL OF APPEAL BRIEF			Docket No. M4065.0239/P239
In re Application of: Larry Hillyer et al.			
Application No. 09/653,561-Conf. #5354	Filing Date August 31, 2000	Examiner H. T. Nguyen	Group Art Unit 2812
Invention: METHOD AND MATERIAL FOR REMOVING ETCH RESIDUE FROM HIGH ASPECT RATIO CONTACT SURFACES			

TO THE COMMISSIONER OF PATENTS:

Transmitted herewith is the Appeal Brief in this application, with respect to the Notice of Appeal filed: March 30, 2006 .

The fee for filing this Appeal Brief is $ 500.00 .

[x] Large Entity [ ] Small Entity

[ ] A petition for extension of time is also enclosed.

The fee for the extension of time is ________ .

[ ] A check in the amount of ________ is enclosed.

[ ] Charge the amount of the fee to Deposit Account No. 04-1073 .
This sheet is submitted in duplicate.

[x] Payment by credit card. Form PTO-2038 is attached.

[x] The Director is hereby authorized to charge any additional fees that may be required or credit any overpayment to Deposit Account No. 04-1073 .
This sheet is submitted in duplicate.

Dated: May 30, 2006

Thomas J. D'Amico
Attorney Reg. No. : 28,371
DICKSTEIN SHAPIRO MORIN & OSHINSKY LLP
2101 L Street NW
Washington, DC 20037-1526
(202) 828-2232

Docket No.: M4065.0239/P239
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Larry Hillyer et al.

Application No.: 09/653,561

Art Unit: 2812

Filed: August 31, 2000

Examiner: Ha T. Nguyen

For: METHOD AND MATERIAL FOR REMOVING ETCH RESIDUE FROM HIGH ASPECT RATIO CONTACT SURFACES

APPEAL BRIEF

MS Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Pursuant to 37 C.F.R. § 41.37(a), this Brief is filed within two months of the Notice of Appeal filed in this case on March 30, 2006, and is in furtherance of said Notice of Appeal.

The fees required under 37 C.F.R. § 41.20(b)(2) are satisfied as indicated in the accompanying TRANSMITTAL OF APPEAL BRIEF.

This Brief contains items under the following headings as required pursuant to 37 C.F.R. § 41.37 and M.P.E.P. § 1206:

I. REAL PARTY IN INTEREST

The real party in interest in this appeal is MICRON TECHNOLOGY, INC., a Corporation of the State of Delaware, and the assignee of this application.

II. RELATED APPEALS, INTERFERENCES, AND JUDICIAL PROCEEDINGS

There are no other appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

A. Total Number of Claims in Application

There are 84 claims pending in this application. A listing of the claims is attached hereto in the Claims Appendix.

B. Current Status of Claims

1. Claims cancelled: 5, 19, 32, 33, 40, 45-49, 51, 83, and 96.

2. Claims withdrawn from consideration but not cancelled: none

3. Claims pending: 1-4, 6-18, 20-32, 34-39, 41-44, 50, 52-82, 84-95, and 97.

4. Claims allowed: none

5. Claims rejected: 1-4, 6-18, 20-32, 34-39, 41-44, 50, 52-82, 84-95, and 97.

C. Claims on Appeal

The claims on appeal are claims 1-4, 6-18, 20-32, 34-39, 41-44, 50, 52-82, 84-95, and 97.

IV. STATUS OF AMENDMENTS

There has been no amendment to the pending claims since the final rejection.

V. SUMMARY OF CLAIMED SUBJECT MATTER

A. Introduction

The invention is directed to methods for removing etch residue, typically a polymer material, from openings, e.g. vias and trenches, particularly High Aspect Ratio (HAR) openings, in semiconductor devices suitable for integrated circuits. Specification page 4, line 11-20. The methods are effective to remove the polymer etch residue, but do not substantially increase the size of the contact opening. Id. The

residue removal utilizes a two-plasma application where a first applied plasma removes a portion of the etch residue and a second applied plasma removes the remainder of the residue not removed by the first plasma. Id. at page 13, line 1-16. The first plasma application is stopped before complete removal of the etch residue so as to avoid producing a silicon rich oxide, such as SiO_2, in the HAR opening. Id. The formation of a silicon rich oxide in the HAR opening would interfere with the post-residue-removal deposition of conductive layers, such as titanium, tungsten or other materials. Id. at page 3, line 8-17. An embodiment of the invention provide methods of forming a contact opening in a semiconductor device, which involves the etch residue cleaning process as discussed above. Id. at page 5, line 1-7. Another embodiment of the invention provides methods for forming an integrated circuit utilizing such a contact opening, which involves the etch residue cleaning process as discussed above. Id. at pages 14-15.

B. Summary of Subject Matter of Claim 1

Independent claim 1 defines a method for removing polymer etch residue from an etched opening in a silicon wafer device. This method includes (FIG. 3) forming an opening (20) in an insulating layer (16), such that a polymer etch residue (22 of FIG. 4) remains within said opening (20) after the opening forming step. Specification page 8, line 17 to page 9, line 10. The method also includes (e.g., FIG. 5) contacting said opening (20) with a first plasma to remove a portion of the polymer etch residue (22), stopping the first plasma, and then (FIG. 6) contacting the opening with a second plasma (e.g. from reactor 26) to remove the polymer etch residue (22) not removed by said first plasma. Specification page 13, line 1-16.

The second plasma is generated from a gas consisting of ammonia and the first plasma is generated from a different gas (i.e., not ammonia). Specification page 13, line 1-10. The second plasma application (FIG. 7) forms a nitride deposit (28). Any of such nitride deposit (28) formed by the second plasma in the opening (20) is removed (see FIG. 8). Specification page 13, line 17-23.

C. Summary of Subject Matter of Claim 15

The method is the same as that discussed above for claim 1, further including that the nitride deposit (28) formed by the second plasma is silicon nitride. Specification page 13, line 17-23. The silicon nitride (28) is removed by a treatment of the opening (20) with at least one of ammonium chloride and phosphoric acid. Specification page 13, line 17-23.

D. Summary of Subject Matter of Claim 16

Independent claim 16 defines a method for removing polymer etch residue from an etched opening in a silicon wafer device. This method includes (FIG. 5) contacting an opening (20) with a plasma consisting of oxygen so as to remove a portion of etch residue (22) present and stopping the oxygen plasma contacting before this polymer etch residue (22) is completely removed. Specification page 13, line 1-16. The method further includes (FIG. 6) removing any remaining etch residue (22) by contacting the opening (20) with a second plasma consisting of a hydrogen containing gas. Specification page 13, line 1-16. The method further includes (FIGs. 7 and 8) treating the opening (20) with at least one of ammonium chloride or phosphoric acid to remove a nitride deposit (28) formed by said second plasma. Specification page 13, line 17-23.

E. Summary of Subject Matter of Claim 29

Independent claim 29 defines a method of forming a contact opening in a semiconductor device. This method includes (FIG. 3) etching a contact opening (20) in an insulative layer (16) in said device down to a polysilicon element (14) of said device. Specification page 8, last paragraph to page 9, first paragraph. The method further includes (FIG. 5) contacting the opening (20) with an oxygen plasma to remove a portion of an etch residue (22). Specification page 13, line 1-16. The method further includes (FIG. 6) removing any remaining etch residue (22) from the etched opening (20) by contacting the opening (20) with a plasma consisting of an hydrogen containing gas in the absence of added oxygen. Specification page 13, line 1-16. The method further includes (FIGs. 7 and 8) treating the contact opening (20) with one of ammonium chloride and phosphoric acid after removing any remaining etch reside (22) with the plasma consisting of an hydrogen containing gas in the absence of added oxygen. Specification page 13, line 17-23.

F. Summary of Subject Matter of Claim 50

Independent claim 50 defines a method of forming an integrated circuit structure (FIG. 1). The method includes (FIGs. 1-3) forming an insulating layer (16) over a polysilicon region (14) and using a fluorine containing gas to form a high aspect ratio contact opening (20) in the insulating layer (16) to expose the polysilicon region (14). Specification page 8, first paragraph to page 9, first paragraph. The method further includes (FIG. 5) removing polymer residue (22) from the contact opening (20) by first contacting the opening (20) with a first plasma, stopping that first contacting, and subsequently (FIG. 6) contacting the opening (20) with a second plasma. Specification page 13, line 1-16. The first plasma consists of a gas other than ammonia

gas and the second plasma consists of ammonia gas. Specification page 13, line 1-10. The first and second plasma treatments are configured to prevent the formation of silicon oxide on a bottom of the contact opening (20). Specification page 13, line 8-9.

The method further includes treating the bottom of the contact opening (20) to remove any nitride (28) formed by the second plasma. Specification page 13, line 17-23. The method further includes (FIG. 8) forming a silicide layer (31) at the bottom of the opening (20) and in contact with the polysilicon layer (14) and forming a conductor (30) in the opening (20) in electrical contact with the silicide layer (31). Specification page 14, first paragraph to page 15, first paragraph.

G. Summary of Subject Matter of Claim 52

Claim 52 depends from claim 50 and defines the same method, but further comprising removing a portion of the polymer residue (22) with oxygen before the second plasma gas, which provides an oxide free bottom of said contact opening (20). Specification page 10, line 15.

H. Summary of Subject Matter of Claim 54

Independent claim 54 defines a method for removing polymer etch residue from an etched opening in a silicon wafer device. The method includes (FIG. 3) forming an opening (20) in an insulating layer (16), wherein a polymer etch residue (22) remains within the opening (20) after the opening forming step. Specification page 8, line 17 to page 9, line 10. The method further includes (FIG. 5) first contacting the opening (20) with a first plasma to remove a portion of the polymer etch residue (22), stopping that first contacting, and subsequently (FIG. 6) contacting the opening (20)

with a second plasma to remove the remainder of the polymer etch residue (22). Specification page 13, line 1-16. The first plasma is generated from a gas other than an hydrogen-containing gas and the second plasma is generated from a gas consisting of hydrogen gas. Specification page 13, line 1-10. The first and subsequent contacting with the first and second plasmas (FIGs. 5 and 6) are configured so as not to leave silicon oxide in the opening after the subsequent contacting. Specification page 13, line 8-9.

I. Summary of Subject Matter of Claim 70

Independent claim 70 defines a method for removing polymer etch residue from an etched opening in a silicon wafer device. The method includes (FIG. 3) forming an opening (20) in an insulating layer (16), wherein a polymer etch residue (22) remains within the opening (20) after the opening forming step. Specification page 8, line 17-page 9, line 10. The method further includes (FIG. 5) removing said polymer etch residue (22) by contacting it with a first plasma and (FIG. 6) a second plasma. Specification page 13, line 1-16. The first plasma is used to remove only a portion of said residue (22) and the second plasma is used to remove the remainder of said polymer etch residue (22). Id. The first plasma is generated from a gas not containing hydrogen and the second plasma is generated from a gas consisting of methane gas. Specification page 13, line 1-16. The removal of the polymer etch residue produces no silicon rich oxide in the opening. Specification page 13, line 8-9.

J. Summary of Subject Matter of Claim 92

Independent claim 92 defines a method of forming an integrated circuit structure (FIG. 1). The method includes (FIGs. 1-3) forming an insulating layer (16)

over a polysilicon region (14) and using a fluorine containing gas to form a high aspect ratio contact opening (20) in the insulating layer (16) to expose the polysilicon region (14). Specification page 8, first paragraph to page 9, first paragraph. The method further includes(FIG. 5) removing polymer residue (22) from the contact opening (20) by first contacting the opening (20) with a first plasma, stopping that first contacting, and (FIG. 6) second contacting the opening (20) with a second plasma. Specification page 13, line 1-16. The first plasma comprises a gas not containing hydrogen and the second plasma consists of hydrogen gas. Specification page 13, line 1-10. Also, the first and second plasmas are configured to not leave silicon oxide in the opening (20) after the first and second contactings. Specification page 13, line 8-9. Also, the second contacting provides an oxide free bottom of the contact opening (20) and does not oxidize the sidewalls or the bottom of the opening (20). Specification page 13, line 11-13.

The method further comprises (FIG. 8) forming a silicide layer (31) at the bottom of the opening (20) in contact with the polysilicon layer (14) and forming a conductor (30) in the opening (20) in electrical contact with the silicide layer (31). Specification page 14, first paragraph to page 15, first paragraph.

K. Summary of Subject Matter of Claim 93

Claim 93 depends from claim 92 and defines the same method, but further comprising removing a portion of the polymer residue (22) with oxygen before the second plasma gas, which provides an oxide free bottom of said contact opening (20). Specification page 10, line 15.

L. Summary of Subject Matter of Claim 95

Independent claim 95 defines a method of forming an integrated circuit structure (FIG. 1). The method includes (FIGs. 1-3) forming an insulating layer (16) over a polysilicon region (14) and using a fluorine containing gas to form an high aspect ratio contact opening (20) in the insulating layer (16) to expose a portion of the polysilicon region (14). Specification page 8, first paragraph to page 9, first paragraph. The method further includes (FIG. 5) removing polymer residue (22) from the contact opening (20) by first contacting the opening (20)with an oxygen plasma, stopping that first contacting, and (FIG. 6) second contacting the opening (20) with a methane-comprising plasma. Specification page 13, line 1-16. The removing of residue (22) prevents the formation of silicon rich oxide at the bottom of the contact opening (20). Specification page 13, line 8-9.

The method further comprises (FIG. 8) forming a silicide layer (31) at the bottom of the opening (20) in contact with the polysilicon layer (14) and forming a conductor (30) in the opening (20) in electrical contact with the silicide layer (31). Specification page 14, first paragraph to page 15, first paragraph.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

A. Whether claim 54 is unpatentable under 35 U.S.C. § 103(a) over U.S. Patent 6,204,192 ("Zhao et al.") in view of U.S. Patent 5,970,376 ("Chen").

B. Whether claims 1-4, 6-18, 20-31, 34-39, 41-44, and 54-91 are unpatentable under 35 U.S.C. § 103(a) over Zhao et al. in view of U.S. Patent 6,277,733 ("Smith").

C. Whether claims 50, 52, 53, 92-95, and 97 are unpatentable under 35 U.S.C. § 103(a) over Zhao et al. in view of Smith and in view of U.S. Patent 6,284,664 ("Kawai") and in view of U.S. Patent 6,291,890 ("Hamada").

VII. ARGUMENT

A. Claim 54 is not unpatentable under 35 U.S.C. § 103(a) over U.S. Patent 6,204,192 ("Zhao et al.") in view of U.S. Patent 5,970,376 ("Chen") because its subject matter would not have been obvious over the combined references and the Office Action fails to make a *prima facie* case for obviousness.

Independent claim 54 defines a method for removing polymer etch residue from an etched opening in a silicon wafer device. Claim 54 recites "forming an opening in an insulating layer, wherein a polymer etch residue remains within said opening after the opening forming step" and "first contacting said opening with a first plasma to remove a portion of said polymer etch residue" and "stopping said first contacting" and "subsequently contacting said opening with a second plasma to remove the remainder of said polymer etch residue, said first plasma being generated from a gas

other than a hydrogen-containing gas and said second plasma being generated from a gas consisting of hydrogen gas, wherein said first and said subsequent contacting with said first and second plasmas are configured so as not to leave silicon oxide in said opening after said subsequent contacting." This is not taught or suggested by Zhao et al. in view of Chen et al.

The Office Action mailed December 30, 2005 (hereinafter the "Office Action"), relies on Zhao et al. as the primary reference in the above-referenced rejection, and in all rejections. Therefore, the argument made here relating to Zhao et al. applies equally to this rejection of claim 54 and to the rejections of each other pending claim.

The Office Action indicates that Zhao et al. discloses a method for removing polymer etch residue from an etched opening in a silicon wafer device where the method includes the steps of: (1) contacting the opening with a first plasma to remove a portion of the etch residue; (2) stopping the first plasma contacting before the polymer etch residue is completely removed; and (3) thereafter removing any remaining residue by contacting the opening using a second plasma consisting of a hydrogen containing gas. Office Action page 2. The Office Action cites col. 4, line 37 to col. 5, line 39 of Zhao et al. for such disclosure. The cited portion of Zhao et al. is reproduced below for the Board's convenience:

4

As shown in FIG. 2, the etching of low k insulation layer **30** to form via **34** can result in the formation of some etch residues **36** in via **34** over the copper surface of the underlying copper interconnect layer. Furthermore, as shown in FIG. 3, the subsequent removal of resist mask **50** may result in further etch residues **38** in via **34** which may include copper oxide formed over the exposed copper surface in the bottom of via **34** during the removal of resist mask **50** by reaction of the resist removal chemicals with such exposed portions of copper interconnect layer **20** at the bottom of via **34**. In any event, the exposed copper surface in the bottom of via **34** must be cleaned to remove such materials, including the copper oxide, prior to filling via **34** with metal to ensure formation of a good ohmic contact between copper interconnect layer **20** and the metal used to fill via **34**.

Conventionally, when the underlying metal interconnect layer was aluminum or some other metal (other than copper), the metal surface was cleaned, to remove such etch residues and metal oxides, using an argon plasma. However, such an argon plasma can also result in the sputtering of some of the exposed metal at the bottom of the via. When this sputtered metal is copper, the resulting redeposition of the sputtered copper onto the via sidewalls can have deleterious effects because the copper atoms, unlike many other metals conventionally used in the construction of integrated circuit structures, will diffuse or migrate into the walls of the insulation material. Thus, it is important that such sputtering of copper be repressed or eliminated.

b. The Hydrogen Plasma Cleaning Step

In accordance with the invention, the exposed copper surfaces at the bottom of via **34** are cleaned to remove oxides

5

and etch residues, including copper oxide residues, from via **34** by use of a hydrogen plasma wherein the hydrogen in the plasma will chemically react with the etch residues, including the copper oxide, rather than sputter the underlying copper. To clean the copper with such a hydrogen plasma, substrate **2** is placed in a high vacuum chamber where it is maintained at a pressure ranging from about 0.1 milliTorr to about 10 milliTorr, typically about 0.5 milliTorr, and at a temperature ranging from about room temperature (20° C.) up to about 300° C., and typically about 150° C. As shown at **6** in FIG. **4**, a negative rf bias is applied to substrate **2** which may range from about −200 volts up to −400 volts, and typically will be about −300 volts. This negative bias is conveniently applied to substrate **2** through the substrate support (not shown) upon which substrate **2** rests in the vacuum chamber. This substrate bias is very important to ensure that the hydrogen atoms in the plasma reach the bottom of via **34**, rather than bombard the sidewalls of via **34**. That is, to ensure that the flow of hydrogen atoms in the via is anisotropic. This is important since the etch residues, and the copper interconnect surface to be cleaned, are at the bottom of via **34**.

Hydrogen gas is then flowed into the chamber, at a flow rate equivalent to a flow of from about 1 standard cubic centimeter per minute (sccm) to about 100 sccm into a 5 liter vacuum chamber and the plasma is then ignited and maintained by a separate conventional plasma power source which may be maintained at a power ranging from about 20 watts to about 400 watts, typically about 300 watts. A small amount of nitrogen gas, e.g., about 100 sccm may also be initially flowed into the vacuum chamber to facilitate ignition of the plasma, but this flow of nitrogen is then shut off as soon as the plasma is ignited. The substrate is exposed to the plasma for a period of time sufficient to remove any remaining etch residues **36**, as well as copper oxide residues **38**, from the exposed portion of copper interconnect layer **20** at the bottom of via **34**. Usually the cleaning time will range from about 5 seconds to about 5 minutes, and typically will be about 1 minute.

As is apparent from a reading of the cited portion of Zhao et al., there is certainly no two-plasma process disclosed, taught or suggested. Instead, a single "Hydrogen Plasma Cleaning Step" is disclosed by Zhao et al. to clean oxides and etch residues from a copper (not polysilicon as recited in many other independent claims) surface at the bottom of a via. Nowhere, particularly at this cited portion, does the primary reference Zhao et al. teach or suggest that a two-plasma residue removal process is possible or desirable. One plasma works well enough according to Zhao et al. and no additional plasma applications are suggested.

The Office Action goes on to indicate that the recited acts, "first contacting said opening with a first plasma to remove a portion of said polymer etch residue" and "stopping said first contacting" are <u>inherently</u> disclosed by Zhao et al. at col. 1, lines 54-63. This portion of the reference is reproduced below for the Board's convenience:

1

face of such a low dielectric constant organo silicon oxide insulation layer is exposed to oxidizing or "ashing" systems, which are used to remove a photoresist mask from the low dielectric constant organo silicon oxide insulation layer, after formation of openings therein, it has been found that the ashing process results in damage to the bonds (severance) between the organic radicals and the silicon atoms adjacent the surfaces of the low dielectric constant organo silicon oxide insulation layer exposed to such an ashing treatment. This severance of the organo-silicon bonds, in turn, results in removal of such organic materials formerly bonded to the silicon atoms along with the organic photoresist materials being removed from the integrated circuit structure. The silicon atoms from which the organic

The Office Action states that "[i]t is *inherent* that some residue is also remov[ed] in the ashing step." Office Action page 3 (italics added). As the Board is well aware, for a rejection based on the inherency doctrine to be properly made, the "Examiner must provide rationale or evidence tending to show inherency," pursuant to M.P.E.P. § 2112. This is wholly lacking in the Office Action. The M.P.E.P. further explains as follows:

> The fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic. <u>In re Rijckaert</u>, 9 F.3d 1531, 1534, 28 USPQ2d 1955, 1957 (Fed. Cir. 1993)(reversed rejection because inherency was based on what would result due to optimization of conditions, not what was necessarily present in the prior art); <u>In re Oelrich</u>, 666 F.2d 578, 581-82, 212 USPQ 323, 326 (CCPA 1981). "To establish inherency, **the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would**

> **be so recognized by persons of ordinary skill.** Inherency, however, **may not be established by probabilities or possibilities**. The mere fact that at certain thing **may** result from a given set of circumstances is **not sufficient**.'" In re Robertson, 169 F.3d 743,745, 49 USPQ2d 1949, 1950-51 (Fed.Cir. 1999).
>
> * * *
>
> "In relying upon the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic **necessarily flows** from the teachings of the applied prior art." Ex parte Levy, 17 USPQ2d 1461, 1464 (Bd. Pat. App. & Inter. 1990)

M.P.E.P. § 1221 (emphasis added).

The Office Action does not meet the imposed burden of establishing that the "ashing step" discussed in the *background* (not the disclosure of the invention) of Zhao et al. (see col. 1, lines 55-65) inherently provides the limitations of the claim, i.e., removing etch residue with a first non-hydrogen-gas-generated plasma. The "ashing step" is explained in the background of Zhao et al. to be a photoresist removal procedure, not a residue removal procedure. Furthermore the photoresist removal procedure, as disclosed by Zhao et al. as part of its intended invention, is explained as *creating* residues (see col. 4, lines 41-42), not removing residues. Therefore, the reference itself shows that an ashing procedure would not necessarily result in removal of etch residue as recited by the claim, but, instead, would create etch residue. Therefore this portion of the Zhao et al. disclosure cannot be used to inherently teach or suggest the claim limitation relating to the first plasma application and the rejection is improper. Additionally, it is clear from the Zhao et al. disclosure that an ashing process is not utilized with the "hydrogen plasma cleaning step," and even if it were, it is not clear that such an ashing step would necessarily perform the steps recited by the claim.

The Office Action also states, "[b]ecause the second plasma reduc[es] any existing silicon oxide, the first and the subsequent contacting with said first and said second plasma prevent the formation of silicon oxide in said opening." Office Action page 3. This statement is not supported by any citation to any part of the reference alleged to disclose, teach or suggest that "said first and subsequent contacting with said first and second plasmas are configured so as not to leave silicon oxide in said opening after said subsequent contacting," as recited by claim 54. In fact, the term silicon oxide is not even present in the Zhao et al. reference. There is simply no discussion in Zhao et al. that silicon oxide formation is to be repressed by any means, much less the configuration of a two-plasma application.

The Office Action indicates that Zhao et al. is incomplete so as not to fully disclose each and every limitation of claim 54 by itself. For the purpose of providing a disclosure of a "first plasma consisting of oxygen" (note this is not a limitation of claim 54), the Office Action cites Chen at col. 10 and 11. Office Action page 3. The cited portion of Chen is reproduced below for the Board's convenience:

about 60 degrees centigrade; and (4) a fluorine containing plasma etchant gas flow rate of from about 30 to about 90 standard cubic centimeters per minute (sccm), for a time period sufficient to completely etch through the blanket low dielectric constant dielectric layer **32** and fully expose the substrate **30**.

Referring now to FIG. **6**, there is shown a schematic cross-sectional diagram illustrating the results of further processing of the microelectronics fabrication whose schematic cross-sectional diagram is illustrated in FIG. **5**. Shown in FIG. **6** is a schematic cross-sectional diagram of a microelectronics fabrication otherwise equivalent to the microelectronics fabrication whose schematic cross-sectional diagram of FIG. **5**, but wherein the fluorocarbon polymer residue layers **38*a*** and **38*b*** have been treated with a fluorocarbon polymer residue layer treatment plasma **42** to form the plasma treated fluorocarbon polymer residue layers **38*a*'** and **38*b*'**. Within the first preferred embodiment of the present invention, the fluorocarbon polymer residue layers **38*a*** and **38*b*** are treated with the fluorocarbon polymer residue layer treatment plasma **42** under conditions such that the plasma treated fluorocarbon polymer residue layers **38*a*'** and **38*b*'**, in comparison with the fluorocarbon polymer residue layers **38*a*** and **38*b***, are more readily stripped from the microelectronics fabrication whose schematic cross-sectional diagram is illustrated in FIG. **6** within an oxygen containing plasma stripping method through which is stripped the patterned photoresist layers **34*a*** and **34*b*** from the patterned low dielectric constant dielectric layers **32*a*** and **32*b***, with attenuated lateral etching of the patterned low dielectric constant dielectric layers **32*a*** and **32*b*** which define the via **40**.

Within the first preferred embodiment of the present invention, the fluorocarbon polymer residue layer treatment plasma **42** preferably employs a reactant gas composition comprising a chemically inert reactant gas chosen from the group of chemically inert reactant gases consisting of argon, neon, xenon and krypton, and mixtures thereof. More preferably, the fluorocarbon polymer residue layer treatment plasma **42** employs a reactant gas composition comprising argon. Most preferably, the fluorocarbon polymer residue layer treatment plasma **42** employs a reactant gas composition consisting of argon. Preferably, the fluorocarbon polymer residue layer treatment plasma **42** also employs: (1) a reactor chamber pressure of from about 30 to about 100 mtorr; (2) a radio frequency power of from about 500 to about 1500 watts at a radio frequency of 13.56 MHZ; (3) a substrate **30** temperature of from about 10 to about 60 degrees centigrade; and (4) an inert gas flow rate of from about 50 to about 150 standard cubic centimeters per minute (sccm).

Referring now to FIG. **7**, there is shown a schematic cross-sectional diagram illustrating the results of further processing of the microelectronics fabrication whose schematic cross-sectional diagram is illustrated in FIG. **6**. Shown in FIG. **7** is a schematic cross-sectional diagram of a microelectronics fabrication otherwise equivalent to the microelectronics fabrication whose schematic cross-sectional diagram is illustrated in FIG. **6**, but wherein the patterned photoresist layers **34*a*** and **34*b***, and the plasma treated fluorocarbon polymer residue layers **38*a*'** and **38*b*'**, have been stripped from the microelectronics fabrication through use of an oxygen containing stripping plasma **44** while simultaneously forming the minimally laterally etched low dielectric constant dielectric layers **32*a*'** and **32*b*'** which define a laterally etched via **40'** of width W2.

Within the first preferred embodiment of the present invention, the oxygen containing stripping plasma **44** may

employ an oxygen containing stripping gas chosen from the group of oxygen containing stripping gases consisting of oxygen, ozone, nitrous oxide and nitric oxide. More preferably, the oxygen containing stripping plasma **44** comprises oxygen. Most preferably, the oxygen containing stripping plasma **44** consists of oxygen. Preferably, the oxygen containing stripping plasma **44** also employs: (1) a reactor chamber pressure of from about 10 to about 20 torr; (2) a radio frequency power of from about 400 to about 750 watts at a radio frequency of 13.56 MHZ; (3) a substrate **30** temperature of from about 200 to about 300 degrees centigrade; and (4) an oxygen flow rate of from about 5000 to about 8000 standard cubic centimeters per minute (sccm).

Upon forming the microelectronics fabrication whose schematic cross-sectional diagram is illustrated in FIG. **7** there is formed a microelectronics fabrication having formed therein through use of a fluorine containing plasma etch method a via through a low dielectric constant dielectric layer formed of a silsesquioxane spin-on-glass (SOG) dielectric material, where the via is formed with attenuated lateral etching of the via when there is stripped from the microelectronics fabrication through an oxygen containing plasma stripping method a patterned photoresist layer employed in defining the via and a fluorocarbon polymer residue layer formed upon a sidewall of the via incident to the fluorine containing plasma etch method.

SECOND PREFERRED EMBODIMENT

Referring now to FIG. **8** to FIG. **11**, there is shown a series of schematic cross-sectional diagrams illustrating the results of forming within an integrated circuit microelectronics fabrication in accord with a more specific preferred embodiment of the present invention which comprises a second preferred embodiment of the present invention an interconnection via through a sandwich composite low dielectric constant dielectric layer formed employing in-part a silsesquioxane spin-on-glass (SOG) dielectric material, with attenuated laterally etching of the interconnection via. Shown in FIG. **8** is a schematic cross-sectional diagram of the integrated circuit microelectronics fabrication at an early stage in its fabrication.

Shown in FIG. **8** is a semiconductor substrate **50** having formed within and upon its surface a pair of isolation regions **52*a*** and **52*b*** which define an active region of the semiconductor substrate **50**. Although it is known in the art of integrated circuit microelectronics fabrication that semiconductor substrates are available with either dopant polarity, various dopant concentrations and several crystallographic orientations, for the second preferred embodiment of the present invention the semiconductor substrate **50** is preferably a (100) silicon semiconductor substrate having an N- or P-doping.

Similarly, although it is also known in the art of integrated circuit microelectronics fabrication that isolation regions may be formed within and/or upon semiconductor substrates to define active regions of those semiconductor substrates through methods including but not limited to isolation region thermal growth methods and isolation region deposition/patterning methods, for the second preferred embodiment of the present invention the isolation regions **52*a*** and **52*b*** are preferably formed within and upon the semiconductor substrate **50** to define the active region of the semiconductor substrate **50** through an isolation region thermal growth method to form the isolation regions **52*a*** and **52*b*** of silicon oxide within and upon the semiconductor substrate **50**.

Regardless of whether Chen teaches or suggests an oxygen plasma, which Applicants do not deny, such disclosure is meaningless in supplementing the disclosure of Zhao et al. for the purpose of providing the subject matter missing from that primary reference in relation to the claimed subject matter.[1] Chen does not provide a teaching or suggestion of a two-plasma treatment to remove etch residue, which is wholly missing from Zhao et al. Chen does not teach or suggest the sequence of plasma applications recited by claim 54. Chen does not teach or suggest plasmas configured so as not to leave silicon oxide after application. For each of these reasons, Chen cannot be combined with Zhao et al. so as to render the claimed invention obvious.

Throughout prosecution of the pending claims, the Examiner has repeatedly ignored the Applicants' arguments that the primary reference teaches away from the claimed subject matter. The Office Action at page 6 indicates that the Examiner has fully considered the Applicants' arguments (made in the Amendment filed with the USPTO on October 6, 2005) that Zhao et al. in view of Chen et al. fails to teach or suggest "first contacting said opening with a first plasma to remove a portion of said polymer etch residue" and "stopping said first contacting" and "subsequently contacting said opening with a second plasma to remove the remainder of said polymer etch residue." In fact, this same part of the Office Action (page 6), the Examiner admits that the references do not expressly disclose use of two plasmas in a residue cleaning method, but the Office Action's argument in support of rejection insists that the Zhao et al. reference does indeed disclose a two-plasma residue cleaning method because it discloses photoresist removal by ashing. This is incorrect and the Office Action fails to establish a *prima facie* case for obviousness.

[1] Chen is directed to a fluorine plasma etch method for forming vias in low dielectric constant material layers. It also discloses an oxygen containing stripping plasma.

The Office Action fails to take into consideration the four basic considerations which apply to obviousness rejections, namely: (A) The claimed invention must be considered as a whole; (B) The references must be considered as a whole and must suggest the desirability and thus the obviousness of making the combination; (C) The references must be viewed without the benefit of impermissible hindsight vision afforded by the claimed invention; and (D) Reasonable expectation of success is the standard with which obviousness is determined. M.P.E.P. § 2141.01.

Considering the *claims* as a whole means that the steps must be looked at as a single process for removing etch residue. Neither Zhao et al. nor Chen et al. teaches or suggest any two-plasma process for this purpose. Many different plasma techniques exist in the prior art, but none specifically use two separate plasmas in a single residue removal process, as recited by the claim.

Considering the *references* as a whole means taking into consideration portions of a reference that would *lead away* from the claimed invention. M.P.E.P. § 2141.02, citing W.L. Gore & Associates, Inc. v. Garlock, Inc., 721 F.2d 1540, 220 U.S.P.Q. 303 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984). When Zhao et al. is considered *as a whole*, as the M.P.E.P. and relevant case law require, it is clear that use of a first plasma (stopped or not) in *conjunction* with a second plasma to remove residue is not taught or suggested.

Further, reading it as a whole, Zhao et al. teaches away from using a two-plasma process to remove residue, i.e., it instructs that use of the ashing technique relied upon in the Office Action as a first plasma treatment is not favored and dedicates the remainder of the specification to disclosing a technique to avoid using the ashing process. Zhao et al. informs a reader that when "an insulation layer is exposed to

oxidizing or 'ashing' systems, which are used to remove a photoresist mask . . . , it has been found that the ashing process results in **damage**." Zhao et al. col. 1, line 55-59 (bold added).

Zhao et al. goes on to state in the same portion of the reference that this *damage* results in "dangling bonds which are very reactive and become water absorption sites if and when the damaged surface is exposed to moisture" Id. col. 2, line 3-5. It is clear that Zhao et al. is not urging the use of this ashing technique in conjunction with the residue removing hydrogen plasma, but is in fact urging that ashing not be used, since nowhere in the description of the intended invention does Zhao et al. ever suggest that ashing is useful or desirable in conjunction with its residue removal plasma. Id. col. 3, line. 53 to col. 7, line 42.

Chen et al. provides no disclosure directed to combining the disfavored Zhao et al. ashing technique with the Zhao et al. plasma step for removing residue. As discussed above, Chen et al. cannot contribute to the Zhao et al. disclosure so as to instruct a person of skill in the art that a first plasma step is used to remove some, but not all etch residue, and is followed by a second plasma step for removing remaining residue. Without using impermissible hindsight using the present application as a roadmap, there is no reason to combine the disparate plasma techniques identified Zhao et al. or to combine the methods of Zhao et al. with those of Chen et al.

Since Zhao et al. in view of Chen et al. does not disclose a method as recited by independent claim 54, this claim (and each claim depending therefrom) is patentable over Zhao et al. and Chen et al. Applicants respectfully request that the 35 U.S.C. § 103(a) rejection of claim 54 be reversed and withdrawn.

B. Claims 1-4, 6-18, 20-31, 34-39, 41-44, and 54-91 are not unpatentable under 35 U.S.C. § 103(a) over Zhao et al. in view of U.S. Patent 6,277,733 ("Smith") since the subject matter of these claims is not taught or suggested in the combined references, because the references are not properly combined for the rejection, and because the Office Action fails to make a *prima facie* case for obviousness.

Independent claim 1 defines a method for removing polymer etch residue from an etched opening in a silicon wafer device and recites, in part, "contacting said opening with a first plasma to remove a portion of said polymer etch residue; stopping said contacting with said first plasma; contacting said opening with a second plasma to remove the polymer etch residue not removed by said first plasma, said second plasma generated from a gas consisting of ammonia and said first plasma being generated from a different gas, said second plasma forming a nitride deposit; and removing any nitride deposits formed by said second plasma in said opening." This method is not taught or suggested by Zhao et al. in view of Smith.

The Zhao et al. reference is utilized in the rejection for the same disclosure thereof as was used in the rejection of claim 54, discussed above. Smith is cited in the Office Action (page 3) for the expressed purpose of supplying a disclosure that ammonia and H_2 are equivalent gasses for removing organic containing materials, referring specifically to col. 4, line 8-26 thereof. The cited portion of Smith is reproduced below for the Board's convenience:

4

Referring to step **312** of FIG. **1** and FIG. **2f**, photoresist **432** is removed. For oxygen sensitive metals such as Cu, this may be accomplished by the method illustrated in co-pending application Ser. No. 09/199,829. In addition, the method of the instant invention can be used at this point to remove the photoresist and any polymer formed on the sides of the via or the trench, the top of conductor **420**, the surface of the dielectric **430**, and any remaining portions of the barriers **420** and **426**. The traditional oxygen photoresist strip step should not be performed in this case, or if the exposed dielectric material is oxygen sensitive. Thus, the wafer should be subjected to a hydrogen-containing plasma so as to remove the photoresist. Preferably, the wafer temperature during this step is on the order of 150 to 350 C (more preferably around 240 to 250 C). While a hydrogen plasma is preferable, one or more forming gases (such as N_2 or Ar) can be added and/or deuterium or other hydrogen-containing plasmas, such as NH_3, N_2H_2, H_2S, or CH_4, or deuterated forms of these gases, for example, may be used instead of hydrogen.

As is apparent from a reading of this portion of Smith and referring back to the reproduced and cited portion of Zhao et al., neither Zhao et al. nor Smith, individually or in combination, teaches or suggest a two-plasma process of removing etch residue, such as the method of independent claim 1, i.e., "contacting said opening with a first plasma to remove a portion of said polymer etch residue; stopping said contacting with said first plasma; contacting said opening with a second plasma to remove the polymer etch residue not removed by said first plasma."

As discussed at length above in relation to the patentability of claim 54 over Zhao et al. combined with Chen et al., Zhao et al. does not teach a two-plasma process for removing etch residue, such as recited by claim 1. It <u>teaches away</u> from using two plasmas and nowhere does it indicate that two plasmas could be useful for removing etch residue or should be combined in a single residue removal (or opening cleaning) process. As also discussed above in relation to the patentability of claim 54, Zhao et al. instructs that the ashing process central to the Office Action's argument is <u>not to be</u>

used because of the danger of damaging the device ultimately formed. Zhao et al. col. 1, line 59 to col. 2, line 5. This does not teach or suggest using two plasmas at all.

Smith, likewise, discloses a process using a (meaning one) plasma to remove residue. Smith col. 4, line 28-48. Further, the two references, Smith and Zhao et al., disclose use of the same plasma to remove residue – a hydrogen-based plasma – not two different plasmas, and certainly not two different plasmas used in a single process. Thus, the combined references fail to teach or suggest "said second plasma generated from a gas consisting of ammonia and said first plasma being generated from a different gas" recited by claim 1.

Additionally, neither reference discloses, teaches or suggests "said second plasma forming a nitride deposit" and/or "removing any nitride deposits formed" as recited by claim 1. There is no indication anywhere in either reference that nitride deposits are even a consideration.

Therefore, since each reference merely teaches using a single, hydrogen-gas-based plasma to remove etch residue, neither teaches or suggest a method of using two plasmas to do this job, neither teaches the sequence of plasma applications, neither teaches forming or removing nitride deposits, and neither teaches or suggests the compositions of two plasmas, as claimed, independent claim 1 is, and each dependent claim therefrom (i.e. claims 2-4 and 6-15), is patentable over Zhao et al. and Smith.

Claim 15 depends from claim 1 and recites "said nitride deposit formed by said second plasma is silicon nitride at a bottom of said opening, said removing said silicon nitride comprising treatment of said opening with at least one of ammonium chloride and phosphoric acid." This is not taught or suggested by Zhao et al. and

Smith. Zhao et al. does not teach or suggest use of ammonium chloride or phosphoric acid to remove nitride deposits after plasma removal of etch residue, much less the specific removal of silicon nitride. Smith cannot supplement the Zhao et al. disclosure to suggest or provide this teaching as it, too, is silent on use of ammonium chloride or phosphoric acid for this purpose.

Independent claim 16 defines a method for removing polymer etch residue from an etched opening in a silicon wafer device and recites "contacting said opening with a plasma consisting of oxygen to remove a portion of said etch residue, stopping said oxygen plasma contacting before said polymer etch residue is completely removed and thereafter removing any remaining said residue by contacting said opening with a second plasma, said second plasma consisting of a hydrogen containing gas, and treating said opening with at least one of ammonium chloride or phosphoric acid to remove a nitride deposit formed by said second plasma." This is not taught or suggested by Zhao et al. and Smith.

As explained above, neither Zhao et al. nor Smith teaches or suggest a two-plasma process for removing etch residue, i.e., "contacting said opening with a plasma consisting of oxygen to remove a portion of said etch residue, stopping said oxygen plasma contacting before said polymer etch residue is completely removed and thereafter removing any remaining said residue by contacting said opening with a second plasma." For this reason alone, the claims are patentable over these references. Additionally, neither reference teaches or suggests the controlling of a first plasma treatment, i.e., "stopping said oxygen plasma contacting before said polymer etch reissue is completely removed," as recited by the claims. Such control is simply not contemplated by Zhao et al. and Smith. Without teaching or suggesting this limitation,

the combined references clearly fail to teach each and every claim limitation or to render the claim obvious.

Also, Zhao et al. does not teach or suggest use of ammonium chloride or phosphoric acid to remove nitride deposits after plasma removal of etch residue. Smith cannot supplement the Zhao et al. disclosure to suggest or provide this teaching as it, too, is silent on use of ammonium chloride or phosphoric acid for this purpose. For this reason as well, independent claim 16, and each claim depending therefrom (i.e., claims 17, 18, 20-28, and 86-88), is patentable over Zhao et al. in view of Smith.

Independent claim 29 defines a method of forming a contact opening in a semiconductor device and recites "a) etching a contact opening in an insulative layer in said device down to a polysilicon element of said device; b) contacting said opening with an oxygen plasma to remove a portion of said etch residue; c) removing any remaining etch residue from said etched opening by contacting said opening with a plasma consisting of a hydrogen containing gas in the absence of added oxygen; and d) treating said contact opening with one of ammonium chloride and phosphoric acid after step (c)." This method is not taught or suggested by Zhao et al. in view of Smith.

As discussed above in relation to the patentability of other claims (e.g., claims 1 and 16), Zhao et al. and Smith fail to teach or suggest a two-plasma treatment in a residue removal process, i.e., "b) contacting said opening with an oxygen plasma to remove a portion of said etch residue; c) removing any remaining etch residue from said etched opening by contacting said opening with a plasma consisting of a hydrogen containing gas in the absence of added oxygen" as recited by the claim. For this reason, independent claim 29 is patentable over these references.

Additionally, neither Zhao et al. nor Smith teaches or suggests "d) treating said contact opening with one of ammonium chloride and phosphoric acid after step (c)," as recited in the claim. For this reason as well, independent claim 29 is patentable over Zhao et al. and Smith, as are dependent claims 30, 31, 34-39, 41-44, and 89-91.

Independent claim 54, as discussed above in relation to the patentability of the claim over Zhao et al. and Chen, is likewise patentable over Zhao et al. in view of Smith, since Smith, like Chen, fails to remedy the deficiencies of the Zhao et al. reference with respect to the limitations of claim 54. Neither Zhao et al. nor Smith teaches or suggests "first contacting said opening with a first plasma to remove a portion of said polymer etch residue" and "stopping said first contacting" and "subsequently contacting said opening with a second plasma to remove the remainder of said polymer etch residue," for the same reasons discussed above in relation to the patentability of claims 1, 16, and 29. Clearly, Zhao et al. fails in this regard, and in fact, *teaches away* from these limitations. Smith too fails since it does not teach a two-plasma technique for removing residue. For the same reasoning as set forth above for the patentability of claims 1, 16, and 29 over Zhao et al. and Smith, independent claim 54, and each claim depending therefrom (i.e., claims 55-69), is patentable over Zhao et al. and Smith.

Independent claim 70 defines a method for removing polymer etch residue from an etched opening in a silicon wafer device and recites, in part, "removing said polymer etch residue by contacting it with a first plasma and a second plasma, said first plasma being used to remove only a portion of said residue, said second plasma being used to remove the remainder of said polymer etch residue, said first plasma generated from a gas not containing hydrogen and said second plasma generated from a gas

consisting of methane gas, wherein said removal of said polymer etch residue produces no silicon rich oxide in said opening." Such a method is not taught or suggested by Zhao et al. and Smith.

Zhao et al. and Smith fail to teach or suggest, expressly or inherently, as discussed at length above in relation to the patentability of claims 1, 16, 29, and 54, the use of a two-plasma technique for removing etch residue. Further, neither Zhao et al. nor Smith teaches or suggests that removal of polymer etch residue produces no silicon rich oxide in an opening. Therefore, for at least these reasons and for the same reasoning as set forth above for the patentability of claims 1, 16, 29, and 54 over Zhao et al. and Smith, independent claim 70, and each dependent claim therefrom (i.e., claims 71-82, 84, and 85), is patentable over these references.

As for the impropriety of combining Zhao et al. and Smith, there would be no motivation to do so absent use of the present application with improper hindsight. Since both references disclose a single-plasma process for residue removal, no person of skill in the art would look to combine the references so as to render the subject matter of the rejected claims obvious. Neither reference's disclosure adds anything to the other's.

Also, as to the failure of the Office Action to present a *prima facie* case of obviousness, once again, reading it as a whole, Zhao et al. <u>teaches away</u> from using a two-plasma process to remove residue, i.e., it instructs that use of the ashing technique relied upon in the Office Action as a first plasma treatment is <u>not favored</u> and dedicates the remainder of the specification to disclosing a technique to <u>avoid</u> using the ashing process. It is clear that Zhao et al. is <u>not</u> urging the use of this ashing technique in conjunction with the residue removing hydrogen plasma, but is in fact urging that ashing <u>not</u> be used, since nowhere in the description of the intended invention does

Zhao et al. ever suggest that ashing is useful or desirable in conjunction with its residue removal plasma. Id. col. 3, line. 53 to col. 7, line 42.

Smith provides no disclosure directed to combining the disfavored Zhao et al. ashing technique with the Zhao et al. plasma step for removing residue. As discussed above, Smith cannot contribute to the Zhao et al. disclosure so as to instruct a person of skill in the art that a first plasma step is used to remove some, but not all etch residue, and is followed by a second plasma step for removing remaining residue. Without using impermissible hindsight using the present application as a roadmap, there is no reason to combine the disparate plasma technique identified Zhao et al. or to combine the methods of Zhao et al. with those of Smith.

Since Zhao et al. in view of Smith does not disclose a method as recited by independent claims 1, 16, 29, 54, and 70, each of these claims (and each claim depending therefrom) is patentable over Zhao et al. and Smith. Applicants respectfully request that the 35 U.S.C. § 103(a) rejection of claims 1-4, 6-18, 20-31, 34-39, 41-44, and 54-91 be reversed and withdrawn.

C. Claims 50, 52, 53, 92-95, and 97 are not unpatentable under 35 U.S.C. § 103(a) over Zhao et al. in view of Smith, further in view of U.S. Patent 6,284,664 ("Kawai"), and further in view of U.S. Patent 6,291,890 ("Hamada") since the subject matter of the claims is not taught or suggested by the combined references, because the combination of these four references in not proper for the outstanding rejection, and because the Office Action fails to make a *prima facie* case for obviousness.

In relation to each claim rejected over Zhao et al., Smith, Kawai, and Hamada, Applicants first point to the presumption that the combination of so many references is improper and lacks suggestion or motivation. For this reason the claims are patentable over the combined references.

Independent claim 50 defines a method of forming an integrated circuit structure and recites, in part, "removing polymer residue from said contact opening by first contacting said opening with a first plasma, stopping said first contacting, and subsequently contacting said opening with a second plasma, said first plasma consisting of a gas other than ammonia gas and said second plasma consisting of ammonia gas, said first and second plasma treatments being configured to prevent the formation of silicon oxide on a bottom of said contact opening; treating said bottom of said contact opening to remove any nitride formed by said second plasma." Such a method is not taught or suggested by Zhao et al. in view of Smith and in view of Kawai and in view of Hamada.

None of Zhao et al., Smith, Kawai, and Hamada teaches or suggests a two-plasma technique for removal of etch residue in a single process, where no silicon rich

oxide is formed during said removal. Such limitations have been discussed at length above in relation to rejections over Zhao et al. and Chen, or Zhao et al. and Smith, and those arguments are incorporated here as if restated in their entirety. Kawai and Hamada cannot supplement Zhao et al. and Smith so as to provide the missing instruction to use two-plasmas in a residue removal method. The teaching or suggestion of such a technique is simply lacking in all four references.

Further, none of the cited references teaches or suggests "said first and second plasma treatments being configured to prevent the formation of silicon oxide on a bottom of said contact opening; treating said bottom of said contact opening to remove any nitride formed by said second plasma." For these reasons, independent claim 50 and dependent claims 52 and 53 are patentable over the references.

Claim 52 depends from independent claim 50 and recites "removing a portion of said polymer residue from said contact opening with oxygen prior to using said gas which provides an oxide free bottom of said contact opening." None of Zhao et al. and Smith and Kawai and Hamada teaches or suggests that its methods result in an "oxide free bottom" of a contact opening." For this reason, in addition to the patentability of claim 50, claim 52 is patentable over the references.

Independent claim 92 defines a method of forming an integrated circuit structure and recites, in part, "removing polymer residue from said contact opening by first contacting said opening with a first plasma, stopping said first contacting, and second contacting said opening with a second plasma, said first plasma comprising a gas not containing hydrogen and said second plasma consisting of hydrogen gas and said first and second plasmas being configured to not leave silicon oxide in said opening after said first and second contacting, wherein said second contacting provides

an oxide free bottom of said contact opening and does not oxidize sidewalls or said bottom of said opening." Such a method is not taught or suggested by Zhao et al. combined with Smith combined with Kawai and combine with Hamada.

The arguments for the patentability of the other independent claims are incorporated here as if restated in their entirety. Among other recited features in this claim, none of the cited references teaches or suggests first and second plasma treatments for removing etch residue in a single process. Additionally, none of the references teaches or suggests that a two-plasma technique can be "configured to not leave silicon oxide in said opening after said first and second contacting." Additionally, none of the cited references teaches or suggests that the removal of polymer etch residue using two-plasma treatments "provides an oxide free bottom of said contact opening and does not oxidize sidewalls or said bottom of said opening." For each of these reasons, independent claim 92 and depending claims 93 and 94 are patentable over the references.

Claim 93 depends from independent claim 92 and recites "removing a portion of said polymer residue from said contact opening with oxygen prior to using said gas which provides an oxide free bottom of said contact opening." None of Zhao et al. and Smith and Kawai and Hamada teaches or suggests that its methods result in an "oxide free bottom" of a contact opening." For this reason, in addition to the patentability of claim 92, claim 93 is patentable over the references.

Independent claim 95 defines a method of forming an integrated circuit structure and recites, in part, "removing polymer residue from said contact opening by first contacting said opening with an oxygen plasma, stopping said first contacting, and second contacting said opening with a methane-comprising plasma, said removing

preventing the formation of silicon rich oxide at the bottom of said contact opening." Such a method is not taught or suggested by the combination of Zhao et al., Smith, Kawai, and Hamada.

As has been discussed above in relation to other claims, none of the cited references teaches or suggests a dual-plasma technique to remove polymer etch residue in a single process, much less one that includes "preventing the formation of silicon rich oxide at the bottom of said contact opening." For at least this reasoning, independent claim 95 and depending claim 97 are patentable over the references.

As for the impropriety of combining Zhao et al. and Smith and Kawai and Hamada, there would be no motivation to do so absent use of the present application with improper hindsight. As stated above, there would be no motivation for one of skill in the art to look to <u>four</u> references so as to render the claimed subject matter obvious. Further, since none of these references disclose other than a single-plasma process for residue removal, no person of skill in the art would look to combine the references to piece together subject matter relating to using more than one plasma for residue removal. None of the reference's disclosures adds anything to the others'.

Also, as to the failure of the Office Action to present a *prima facie* case of obviousness, once again, reading it as a whole, Zhao et al. <u>teaches away</u> from using a two-plasma process to remove residue, i.e., it instructs that use of the ashing technique relied upon in the Office Action as a first plasma treatment is <u>not favored</u> and dedicates the remainder of the specification to disclosing a technique to <u>avoid</u> using the ashing process. It is clear that Zhao et al. is <u>not</u> urging the use of this ashing technique in conjunction with the residue removing hydrogen plasma, but is in fact urging that ashing <u>not</u> be used, since nowhere in the description of the intended invention does

Zhao et al. ever suggest that ashing is useful or desirable in conjunction with its residue removal plasma. Id. col. 3, line. 53 to col. 7, line 42.

Neither Smith nor Kawai nor Hamada provides disclosure directed to combining the disfavored Zhao et al. ashing technique with the Zhao et al. plasma step for removing residue. As discussed above, none of Smith, Kawai and Hamada can contribute to the Zhao et al. disclosure so as to instruct a person of skill in the art that a first plasma step is used to remove some, but not all etch residue, and is followed by a second plasma step for removing remaining residue. Without using impermissible hindsight using the present application as a roadmap, there is no reason to combine the disparate plasma technique identified Zhao et al. or to combine the methods of Zhao et al. with those of Smith, Kawai and Hamada.

Since Zhao et al. in view of Smith in view of Kawai and in view of Hamada does not disclose a method as recited by independent claims 50, 92, and 95, each of these claims (and each claim depending therefrom) is patentable over Zhao et al. and Smith. Applicants respectfully request that the 35 U.S.C. § 103(a) rejection of claims 50, 52, 53, 92-95, and 97 be reversed and withdrawn.

D. Conclusion

In view of the above, Applicants believe the pending application is in condition for allowance. Applicants respectfully request that the outstanding rejection of claims be REVERSED by the Board and withdrawn by the Examiner and that a Notice of Allowance be immediately mailed.

Dated: May 30, 2006

Respectfully submitted,

By________________________
Thomas J. D'Amico
Registration No.: 28,371
Ryan H. Flax
Registration No.: 48,141
DICKSTEIN SHAPIRO MORIN & OSHINSKY LLP
2101 L Street NW
Washington, DC 20037-1526
(202) 785-9700
Attorney for Applicants

Attachments:
- Claims Appendix
- Evidence Appendix
- Related Proceedings Appendix

CLAIMS APPENDIX

The following is a listing of the claims pending in U.S. Patent Application 09/653,561:

1. A method for removing polymer etch residue from an etched opening in a silicon wafer device comprising:

forming an opening in an insulating layer, wherein a polymer etch residue remains within said opening after the opening forming step;

contacting said opening with a first plasma to remove a portion of said polymer etch residue;

stopping said contacting with said first plasma;

contacting said opening with a second plasma to remove the polymer etch residue not removed by said first plasma, said second plasma generated from a gas consisting of ammonia and said first plasma being generated from a different gas, said second plasma forming a nitride deposit; and

removing any nitride deposits formed by said second plasma in said opening.

2. The method of claim 1, wherein said opening is a High Aspect Ratio (HAR) contact opening.

3. The method of claim 2, wherein said contacting with said first and second plasmas is performed under conditions effective to remove said etch residue without substantially increasing the size of said opening.

4. The method of claim 3, wherein said opening is contacted with said second plasma in the absence of oxygen.

5. (Cancelled).

6. The method of claim 2, wherein said contacting with said second plasma is done at a temperature within the range of about 250-500° C.

7. The method of claim 6, wherein said contacting with said second plasma is performed in a plasma reactor within a power reactor range of about 500 - 2500 watts.

8. The method of claim 7, wherein said contacting with said second plasma is performed within a power range of about 1500 - 2000 watts.

9. The method of claim 7, wherein said contacting with said second plasma is performed with an ammonia gas flow rate within the range of about 500 to 1000 SCCM.

10. The method of claim 9, wherein said contacting with said second plasma is performed at power of about 1900 watts and a temperature of about 350°C.

11. The method of claim 10, wherein said contacting with said second plasma is performed with an ammonia gas flow rate of about 750 SCCM.

12. The method of claim 9, wherein said contacting with said second plasma is performed for a period of less than about 100 seconds.

13. The method of claim 12, wherein said contacting is performed for a period of not more than about 75 seconds.

14. The method of claim 1, further comprising forming a conductive layer at a bottom of said opening following said contacting step with said second plasma.

15. The method of claim 1, wherein said nitride deposit formed by said second plasma is silicon nitride at a bottom of said opening, said removing said silicon nitride comprising treatment of said opening with at least one of ammonium chloride and phosphoric acid.

16. A method for removing polymer etch residue from an etched opening in a silicon wafer device, comprising the steps of:

contacting said opening with a plasma consisting of oxygen to remove a portion of said etch residue, stopping said oxygen plasma contacting before said polymer etch residue is completely removed and thereafter removing any remaining said residue by contacting said opening with a second plasma, said second plasma consisting of a hydrogen containing gas, and treating said opening with at least one of ammonium chloride or phosphoric acid to remove a nitride deposit formed by said second plasma.

17. The method of claim 16, wherein said contact opening is an High Aspect Ratio (HAR) opening, and said second plasma contacting step is performed under conditions effective to remove said etch residue without substantially increasing the size of said opening.

18. The method of claim 17, wherein said second plasma contacting occurs in the absence of oxygen.

19. (Cancelled).

20. The method of claim 18, wherein said second plasma contacting is performed at a temperature within the range of about 250 – 500° C.

21. The method of claim 18, wherein said second plasma contacting is performed in a reactor operating in a power range of about 500-5000 watts.

22. The method of claim 20, wherein said second plasma contacting is performed at a temperature of about 350°C.

23. The method of claim 21, wherein said reactor power is about 1900 watts.

24. The method of claim 21, wherein said second plasma contacting is performed at a flow rate within the range of about 100 to 4000 SCCM.

25. The method of claim 16, wherein said second plasma contacting is performed for a period of time sufficient to remove said residue from a bottom of said opening.

26. The method of claim 25, wherein said bottom of said opening is not oxidized during said second plasma contacting step.

27. The method of claim 24, wherein said contacting is performed for a period of less than about 100 seconds.

28. The method of claim 27, wherein said contacting is performed for a period of not more than about 75 seconds.

29. A method of forming a contact opening in a semiconductor device, comprising:

    a) etching a contact opening in an insulative layer in said device down to a polysilicon element of said device;

    b) contacting said opening with an oxygen plasma to remove a portion of said etch residue;

    c) removing any remaining etch residue from said etched opening by contacting said opening with a plasma consisting of a hydrogen containing gas in the absence of added oxygen; and

    d) treating said contact opening with one of ammonium chloride and phosphoric acid after step (c).

30. The method of claim 29, wherein said contacting said opening with an oxygen plasma and said contacting said opening with a plasma consisting of a hydrogen containing gas in the absence of added oxygen is performed under conditions effective to remove said etch residue without substantially increasing the size of said opening.

31. The method of claim 30, wherein said contacting said opening with an oxygen plasma and said contacting said opening with a plasma consisting of a hydrogen containing

gas in the absence of added oxygen is performed under conditions which do not oxidize said opening.

32-33. (Cancelled).

34. The method of claim 29, wherein said contacting said opening with a plasma consisting of a hydrogen containing gas in the absence of added oxygen is done in a plasma reactor at a temperature within the range of about 250 - 500° C, with a reactor power within the range of about 500 – 2500 watts, with an ammonia gas flow rate of about 500 to 1000 SCCM, and for a period of no more than 100 seconds.

35. The method of claim 34, wherein said contacting said opening with a plasma consisting of a hydrogen containing gas in the absence of added oxygen is performed within a reactor power range of about 1500 - 2000 watts.

36. The method of claim 34, wherein said contacting said opening with a plasma consisting of a hydrogen containing gas in the absence of added oxygen is performed with a reactor power at about 1900 watts and a temperature of about 350°C.

37. The method of claim 34, wherein said contacting said opening with a plasma consisting of a hydrogen containing

gas in the absence of added oxygen is performed at a gas flow rate of 750 SCCM.

38. The method of claim 35, wherein said contacting said opening with a plasma consisting of a hydrogen containing gas in the absence of added oxygen is performed for a period of not more than about 75 seconds.

39. The method of claim 29, further comprising forming a silicide layer at the bottom of said contact opening following said contacting operation.

40. (Cancelled).

41. The method of claim 29, wherein an insulating layer is formed on said device prior to said etching and said etching forms a contact hole in said insulating layer.

42. The method of claim 41, wherein said etching is dry etching.

43. The method of claim 42, wherein said dry etching is performed using at least one fluorine-containing gas.

44. The method of claim 43, wherein said fluorine-containing gas is at least one gas selected from the group consisting of CH_2F_2, CHF_3, C_2F_6, C_2HF_5, and CH_3F.

45-49. (Cancelled).

50. A method of forming an integrated circuit structure comprising:

forming an insulating layer over a polysilicon region;

using a fluorine containing gas to form a high aspect ratio contact opening in said insulating layer to expose said polysilicon region;

removing polymer residue from said contact opening by first contacting said opening with a first plasma, stopping said first contacting, and subsequently contacting said opening with a second plasma, said first plasma consisting of a gas other than ammonia gas and said second plasma consisting of ammonia gas, said first and second plasma treatments being configured to prevent the formation of silicon oxide on a bottom of said contact opening;

treating said bottom of said contact opening to remove any nitride formed by said second plasma;

forming a silicide layer at the bottom of said opening in contact with said polysilicon layer;

forming a conductor in said opening in electrical contact with said silicide layer.

51. (Cancelled).

52. A method as in claim 50 further comprising removing a portion of said polymer residue from said contact opening with oxygen prior to using said gas which provides an oxide free bottom of said contact opening.

53. A method as in claim 50 wherein said silicide layer is a titanium silicide layer.

54. A method for removing polymer etch residue from an etched opening in a silicon wafer device comprising:

forming an opening in an insulating layer, wherein a polymer etch residue remains within said opening after the opening forming step;

first contacting said opening with a first plasma to remove a portion of said polymer etch residue;

stopping said first contacting; and

subsequently contacting said opening with a second plasma to remove the remainder of said polymer etch residue, said first plasma being generated from a gas other than a hydrogen-containing gas and said second plasma being generated from a gas consisting of hydrogen gas, wherein said first and said subsequent contacting with

said first and second plasmas are configured so as not to leave silicon oxide in said opening after said subsequent contacting.

55. The method of claim 54, wherein said opening is a High Aspect Ratio (HAR) contact opening.

56. The method of claim 55, wherein said subsequent contacting is performed under conditions effective to remove said etch residue without substantially increasing the size of said opening.

57. The method of claim 56, wherein said opening is contacted with hydrogen gas plasma in the absence of oxygen during said subsequent contacting.

58. The method of claim 55, wherein said subsequent contacting is done at a temperature within the range of about 250-500° C.

59. The method of claim 58, wherein said subsequent contacting is performed in a plasma reactor within a power reactor range of about 500-2500 watts.

60. The method of claim 59, wherein said subsequent contacting is performed within a power range of about 1500-2000 watts.

61. The method of claim 59, wherein said subsequent contacting is performed with a hydrogen gas flow rate within the range of about 500 to 1000 SCCM.

62. The method of claim 61, wherein said subsequent contacting is performed at power of about 1900 watts and a temperature of about 350°C.

63. The method of claim 62, wherein said subsequent contacting is performed with a hydrogen gas flow rate of about 750 SCCM.

64. The method of claim 61, wherein said subsequent contacting is performed for a period of less than about 100 seconds.

65. The method of claim 64, wherein said subsequent contacting is performed for a period of not more than about 75 seconds.

66. The method of claim 54, further comprising forming a conductive layer at a bottom of said opening following said subsequent contacting step.

67. The method of claim 54, wherein said opening is not oxidized during the removal of said polymer etch residue.

68. The method of claim 54, wherein said subsequent plasma contacting is performed for a period of time sufficient to remove said residue from a bottom of said opening.

69. The method of claim 54, wherein a bottom of said opening is not oxidized during said subsequent plasma contacting step.

70. A method for removing polymer etch residue from an etched opening in a silicon wafer device comprising:

forming an opening in an insulating layer, wherein a polymer etch residue remains within said opening after the opening forming step; and

removing said polymer etch residue by contacting it with a first plasma and a second plasma, said first plasma being used to remove only a portion of said residue, said second plasma being used to remove the remainder of said polymer etch residue, said first plasma generated from a gas not containing hydrogen and said second plasma generated from a gas consisting of methane gas, wherein said removal of said polymer etch residue produces no silicon rich oxide in said opening.

71. The method of claim 70, wherein said opening is a High Aspect Ratio (HAR) contact opening.

72. The method of claim 71, wherein said contacting is performed under conditions effective to remove said etch residue without substantially increasing the size of said opening.

73. The method of claim 72, wherein said opening is contacted with said methane gas plasma in the absence of oxygen.

74. The method of claim 71, wherein said contacting is done at a temperature within the range of about 250 - 500° C.

75. The method of claim 74, wherein said contacting is performed in a plasma reactor within a power reactor range of about 500 - 2500 watts.

76. The method of claim 75, wherein said contacting is performed within a power range of about 1500 - 2000 watts.

77. The method of claim 75, wherein said contacting is performed with a methane gas flow rate within the range of about 500 to 1000 SCCM.

78. The method of claim 77, wherein said contacting is performed at power of about 1900 watts and a temperature of about 350°C.

79. The method of claim 78, wherein said contacting is performed with a methane gas flow rate of about 750 SCCM.

80. The method of claim 77, wherein said contacting is performed for a period of less than about 100 seconds.

81. The method of claim 80, wherein said contacting is performed for a period of not more than about 75 seconds.

82. The method of claim 70, further comprising forming a conductive layer at a bottom of said opening following said second plasma use.

83. (Cancelled).

84. The method of claim 70, wherein said first and second plasma contacting is performed for a period of time sufficient to remove said residue from a bottom of said opening.

85. The method of claim 70, wherein a bottom of said opening is not oxidized during said second plasma contacting step.

86. The method of claim 16, wherein said hydrogen containing gas is ammonia gas.

87. The method of claim 16, wherein said hydrogen containing gas is hydrogen gas.

88. The method of claim 16, wherein said hydrogen containing gas is methane gas.

89. The method of claim 29, wherein said hydrogen containing gas is ammonia gas.

90. The method of claim 29, wherein said hydrogen containing gas is hydrogen gas.

91. The method of claim 29, wherein said hydrogen containing gas is methane gas.

92. A method of forming an integrated circuit structure comprising:

forming an insulating layer over a polysilicon region;

using a fluorine containing gas to form a high aspect ratio contact opening in said insulating layer and expose said polysilicon region;

removing polymer residue from said contact opening by first contacting said opening with a first plasma, stopping said first contacting, and second contacting said opening with a second plasma, said first plasma

comprising a gas not containing hydrogen and said second plasma consisting of hydrogen gas and said first and second plasmas being configured to not leave silicon oxide in said opening after said first and second contacting, wherein said second contacting provides an oxide free bottom of said contact opening and does not oxidize sidewalls or said bottom of said opening;

forming a silicide layer at the bottom of said opening in contact with said polysilicon layer;

forming a conductor in said opening in electrical contact with silicide layer.

93. A method as in claim 92, further comprising removing a portion of said polymer residue from said contact opening with oxygen prior to said second contacting which provides an oxide free bottom of said contact opening.

94. A method as in claim 92, wherein said silicide layer is a titanium silicide layer.

95. A method of forming an integrated circuit structure comprising:

forming an insulating layer over a polysilicon region;

using a fluorine containing gas to form a high aspect ratio contact opening in said insulating layer to expose a portion of said polysilicon region;

removing polymer residue from said contact opening by first contacting said opening with an oxygen plasma, stopping said first contacting, and second contacting said opening with a methane-comprising plasma, said removing preventing the formation of silicon rich oxide at the bottom of said contact opening;

forming a silicide layer at the bottom of said opening in contact with said polysilicon layer;

forming a conductor in said opening in electrical contact with silicide layer.

96. (Cancelled).

97. A method as in claim 95, wherein said silicide layer is a titanium silicide layer.

EVIDENCE APPENDIX

None.

RELATED PROCEEDINGS APPENDIX

None.